

**FOUNDATION INVESTIGATION REPORT
PAGWACHUAN RIVER TRIBUTARY CULVERT REPLACEMENT
HIGHWAY 11
DISTRICT OF THUNDER BAY, ONTARIO**

G.W.P. 6134-04-00, SITE No. 48E-69/C

Geocres Number: 42F-31

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the proposed location of the replacement culvert carrying Highway 11 over the Pagwachuan River tributary located approximately 70 km east of Longlac, in the District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM), under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

2 SITE DESCRIPTION

The existing Pagwachuan River Tributary culvert is located approximately 70 km (by highway) east of Longlac, Ontario and about 12 km west of the intersection of Highway 11 and South Pagwachuan Road. Pagwachuan River Tributary is a tributary of the main Pagwachuan River, which runs in a meandering west to east direction, south of Highway 11. At the existing Highway 11 crossing, the tributary flows in a general north to south direction before meeting the main Pagwachuan River.

The culvert under the existing highway embankment consists of a 25.5 m long timber culvert with twin 2.1 by 1.75 m openings and the highway embankment is approximately 2.1 m high. Preliminary drawings provided by MMM indicate a water level of Elev. 222.4 m in the Pagwachuan River Tributary in April 2011.

The surrounding lands are densely treed with grass and shrubs in close proximity to the highway. Photographs in Appendix C show the existing Pagwachuan River Tributary culvert and the general nature of the site.

The site lies within the physiographic region known as the Quetico Subprovince of the Superior Province of the Canadian Shield. Based on Ontario Geological Survey (OGS) Map s365, titled “Algoma-Cochrane Surficial Geology”, dated 1962, the site is located in an area consisting of lacustrine deposits of varved clay and silt, fine sand, and clayey till ground moraine. The bedrock in the region is early Precambrian and based on OGS Map 2543, titled “Bedrock Geology of Ontario, East-Central Sheet”, dated 1991, the bedrock consists of metasedimentary bedrock (paragneiss and migmatites).

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out between June 7 and 10, 2014. The investigation comprised drilling and sampling four boreholes identified as Boreholes PCT-01 to PCT-04 along the proposed replacement culvert alignment. Boreholes PCT-01 and PCT-04 were drilled near the proposed inlet and outlet respectively, and Boreholes PCT-02 and PCT-03 were drilled on the west and east sides of the culvert alignment through the existing highway embankment.

The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

The boreholes were advanced to depths of 12.3 to 14.5 m (Elev. 210.3 to 209.5 m), including recovery of 2.5 to 3.5 m of bedrock core. The drilling was carried out using a track mounted CME 55 drill rig with NW casing and wash boring techniques. Soil samples were obtained at selected intervals in the boreholes using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was conducted to further assess the undrained shear strength of the cohesive deposits. Sampling of the underlying rock was conducted using NQ size diamond coring equipment.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber’s technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber’s laboratory for further examination and testing. All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Standpipe piezometers were installed in two boreholes to measure groundwater levels. The piezometers were subsequently decommissioned in general accordance with MOE Regulation 903

following completion of the final water level reading. The piezometer installation and borehole completion details are summarized in Table 3.1.

Table 3.1 – Borehole Completion and Piezometer Installation Details

Borehole	Piezometer Tip Depth/ Elev. (m)	Completion and Installation Details
PCT-01	8.5 / 214.0	19 mm diameter piezometer installed with filter sand from 8.5 m to 6.7 m, bentonite holeplug from 6.7 to 5.2 m, then cuttings and bentonite holeplug to surface.
PCT-02	None installed	Backfilled with bentonite holeplug to 0.6m, concrete to 0.1 m, then asphalt cold patch to surface.
PCT-03	None installed	Backfilled with bentonite holeplug to 0.6m, concrete to 0.1 m, then asphalt cold patch to surface.
PCT-04	8.8 / 213.2	19 mm diameter piezometer installed with filter sand from 8.8 m to 3.7 m, then bentonite holeplug from 3.7 m to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and sieve) and Atterberg Limits testing, where appropriate. The results of these tests are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact bedrock to assist in evaluation of the compressive strength of the bedrock. The results of point load tests on the rock core samples are presented on the Record of Borehole sheets in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

In general, the subsurface stratigraphy encountered at the culvert site consisted of existing embankment fill overlying thin layers of sand and silty clay, underlain by deposits of silt to sandy silt and silty clay. The silty clay was underlain by discontinuous units of silty clay till and sand and gravel overlying bedrock. Peaty topsoil was encountered at the ground surface in the off-road boreholes, and a thin layer of buried peat was identified below the embankment fill. More detailed descriptions of the individual strata are presented below.

5.1 Pavement Structure

A pavement structure comprising 100 to 125 mm of asphalt overlying 400 to 900 mm of sand and gravel was encountered at the highway surface in Boreholes PCT-02 and PCT-03.

SPT N-values of 54 and 67 blows per 0.3 m penetration were recorded in the sand and gravel fill, indicating a very dense relative density. Moisture contents of the sand and gravel fill ranged from 3 to 11%.

One sample of the sand and gravel fill was selected for laboratory grain size analysis testing. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet included in Appendix A. The grain size distribution curve for the sample is plotted on Figure B1 of Appendix B.

Gravel %	36
Sand %	57
Silt and Clay %	7

5.2 Sand Fill

Existing embankment fill consisting of sand with some gravel and trace silt was encountered beneath the sand and gravel fill in Boreholes PCT-02 and PCT-03. The thickness of the sand fill was 1.8 and 1.6 m with a lower boundary encountered at depths of 2.3 and 2.6 m (Elev. 221.7 and 221.4 m).

SPT N-values recorded in the fill ranged from 8 to 24 blows per 0.3 m penetration, indicating a loose to compact relative density. Moisture contents of the sand fill ranged from 10 to 16%.

One sample of the sand fill was selected for laboratory grain size analysis testing. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet included in Appendix A. The grain size distribution curve for the sample is plotted on Figure B2 of Appendix B.

Gravel %	15
Sand %	71
Silt and Clay %	14

5.3 Topsoil and Peat

A 200 to 300 mm thick layer of peaty topsoil was encountered at the ground surface in Boreholes PCT-01 and PCT-04 drilled adjacent to the roadway embankment. Moisture contents of 24% and 40% were measured in this layer.

A 200 mm thick layer of peat was encountered beneath the sand fill in Borehole PCT-02. The lower boundary of the peat layer was encountered at a depth of 2.5 m (Elev. 221.5 m). A moisture content of 391% was measured in this material. In Borehole PCT-03, a seam of organic material was noted at the base of the sand fill at 2.6 m depth (Elev. 221.4).

5.4 Silty Clay

A relatively thin layer of silty clay with trace sand and gravel was encountered below the topsoil and a thin sand layer in Borehole PCT-01, the peat layer in Borehole PCT-02, the sand fill in Borehole PCT-03 and the topsoil in Borehole PCT-04. The clay was described as brown to brownish grey, and contained trace organics. The thickness of this layer ranged from 0.4 to 1.2 m with a lower boundary encountered at depths of 0.8 to 3.3 m (Elev. 220.7 to 221.2 m).

SPT N-values of 0 to 5 blows for 0.3 m penetration were recorded in tests carried out within or partially within the clay, indicating a very soft to firm consistency. Locally in Borehole PCT-03, an N-value of 22 blows for 0.3 m penetration was recorded, indicating a stiff consistency. The moisture content of the deposit ranged from 18 to 46%.

5.5 Sand to Silty Sand

A layer consisting of silty sand with some gravel to sand with some silt and gravel (to gravelly) was encountered beneath the silty clay layer in Boreholes PCT-01 to PCT-03. The thickness of the sand layer ranged from 0.3 to 0.8 m with a lower boundary encountered at depths of 2.0 to 4.1 m (Elev. 220.5 to 219.9 m). A 0.3 m thick sand layer with organics was also encountered below the topsoil in Borehole PCT-01.

SPT N-values recorded partially within the sand layer ranged from 8 to 13 blows for 0.3 m penetration, indicating a loose to compact condition. Measured moisture contents in the silty sand to sand layer ranged from 7 to 19%.

Three samples of the silty sand to sand layer were selected for laboratory grain size analysis testing. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for the samples are plotted on Figure B3 of Appendix B.

Gravel %	13 to 26
Sand %	54 to 63
Silt and Clay %	17 to 25

5.6 Silt to Sandy Silt

A layer varying in composition from silt, some clay, trace sand to sandy silt, trace clay, trace gravel was encountered beneath the silty clay in Borehole PCT-04 and the silty sand to sand layer in the remaining boreholes. The silt/sandy silt was described as light brown to dark greyish brown, and contained clay seams in Boreholes PCT-01 and PCT-02, as well a wood pieces in the upper 0.6 m of this layer in Borehole PCT-04. The thickness of this layer ranged from 1.5 to 3.1 m with a lower boundary encountered at depths of 3.0 to 6.5 m (Elev. 219.0 to 217.5 m).

SPT N-values recorded in the silt to sandy silt typically ranged from 6 to 10 blows per 0.3 m penetration, indicating a loose relative density. Locally, an N-value of 1 blow for 0.3 m (very loose) was recorded in the upper 0.6 m of this layer in Borehole PTC-04, and an N-value of 19 blows for 0.3 m (compact) was obtained in Borehole PCT-02. Measured moisture contents typically ranged from 15 to 25%, with one value of 65% from Borehole PCT-04.

Three samples of the silt to sandy silt layer were selected for laboratory grain size analysis testing. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for the samples are plotted on Figure B4 of Appendix B.

Gravel %	0 to 2
Sand %	6 to 38
Silt %	50 to 78
Clay %	8 to 16

5.7 Lower Silty Clay

A lower layer of silty clay was encountered beneath the silt to sandy silt layer in all boreholes. The silty clay was described as brown, dark brown or greyish brown, typically contained silt seams, and in some zones contained trace sand and gravel. The thickness of this layer varied between 3.7 and 5.1 m with a lower boundary encountered at depths of 7.8 to 11.2 m (Elev. 214.7 to 212.8 m).

SPT N-values of 0 to 16 blows per 0.3 m penetration was recorded in the silty clay. In situ shear vane testing indicated undrained shear strengths varying from 31 to 53 kPa. Based on this data, the consistency of the silty clay is generally firm to stiff. The measured moisture contents in this layer varied between 20 and 57%.

The results of grain size distribution analyses conducted on five samples of the silty clay are presented on the Record of Borehole sheets in Appendix A and on Figure B5 in Appendix B. The results of Atterberg Limits testing conducted on the samples are

presented on the Record of Borehole sheets and plotted on Figure B7 of Appendix B. The results are summarized below.

Gravel %	0 to 2
Sand %	0 to 9
Silt %	34 to 59
Clay %	37 to 66
Liquid Limit %	26 to 46
Plastic Limit %	14 to 20

The results indicate that the silty clay displays low to medium plasticity with a group symbol of CL to CI.

5.8 Silty Clay Till

A discontinuous deposit of silty clay till was encountered beneath the silty clay in Borehole PCT-01. This deposit was 1.4 m thick and overlies bedrock at 9.2 m depth (Elev. 213.3). Till-like layers were also noted within the lower part of the silty clay stratum in Boreholes PCT-03 and PCT-04.

An SPT N-value of 11 blows per 0.3 m penetration was recorded in the silty clay till, indicating a stiff consistency. Moisture contents of 9% and 13% were measured in this layer.

Glacial tills inherently contain cobbles and boulders.

5.9 Sand and Gravel to Gravelly Sand

A deposit of sand and gravel to gravelly sand was encountered beneath the lower silty clay in Boreholes PCT-02 and PCT-04. This layer was 0.8 and 1.7 m thick and overlies bedrock at depths of 10.3 and 9.8 m (Elev. 213.7 to 212.2 m).

An SPT N-value of 30 blows for 0.3 m penetration was recorded at the upper boundary of the sand and gravel in Borehole PCT-02, indicating a compact to dense condition. A single SPT N-value of 11 blows per 0.3 m of penetration was recorded in Borehole PCT-04, indicating a compact relative density. Moisture contents of 10 and 17% were measured in this deposit.

One sample of the deposit was selected for laboratory grain size analysis testing. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet included in Appendix A. The grain size distribution curve for the sample is plotted on Figure B6 of Appendix B.

Gravel %	21
Sand %	72
Silt and Clay %	7

5.10 Bedrock

Bedrock was proven in all four boreholes by coring 2.5 to 3.5 m into the bedrock. The depths and elevations of the bedrock surface encountered in the boreholes are summarized in Table 5.1.

Table 5.1 – Depths and Elevations of Bedrock Surface

Borehole	Bedrock Surface Proven by Coring	
	Depth (m)	Elevation (m)
PCT-01	9.2	213.3
PCT-02	10.3	213.7
PCT-03	11.2	212.8
PCT-04	9.8	212.2

The bedrock was described as dark grey migmatitic gneiss with white bands. The total core recovery (TCR) ranged from 97 to 100% and the rock quality designation (RQD) varied between 84 and 100%, indicating a good to excellent rock quality. The fracture index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 5.

The estimated unconfined compressive strength (UCS) of the rock, interpreted from the results of point load tests, varied from 114 to 251 MPa, indicating a very strong strength classification.

5.11 Water Levels

Standpipe piezometers were installed in two boreholes to monitor groundwater levels after completion of drilling. A summary of the recorded groundwater levels is provided below.

Table 5.2 - Groundwater Level Measurements

Borehole	Date	Groundwater Level		Comment
		Depth (m)	Elevation	
PCT-01	June 8, 2014	0.8	221.7	In piezometer
	June 9, 2014	0.9	221.6	
	June 10, 2014	1.0	221.5	
	June 12, 2014	1.2	221.4	
PCT-04	June 9, 2014	0.2	221.8	In piezometer
	June 10, 2014	0.3	221.7	
	June 12, 2014	0.3	221.7	

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

The groundwater level is also expected to be influenced by the water level in the Pagwachuan River Tributary, which is shown on the preliminary drawings provided by MMM to be at Elev. 222.4 at the outlet in April 2011.

6 MISCELLANEOUS

In general, the borehole locations were positioned in the field by Thurber staff and were established relative to site features. The co-ordinates and ground surface elevations at the boreholes were inferred from the MMM Group Limited General Arrangement drawing dated March 2014.

Eastern Ontario Diamond Drilling Limited from Hawkesbury, Ontario supplied a track mounted CME 55 drill rig and conducted the drilling, sampling and in-situ testing operations.

Full time supervision of the field activities was carried out by Mr. Matthew Whalen of Thurber. Overall supervision of the field program was conducted by Mr. Mark Farrant, P. Eng.

Interpretation of the data and preparation of this report were carried out by Mr. Michael Eastman and Mr. Murray R. Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS


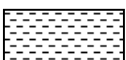

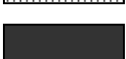

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery:(SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation:(RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity


ONTMT4S 1197.GPJ 2012TEMPLATE(MTO).GDT 8/13/14

RECORD OF BOREHOLE No PCT-01

2 OF 2

METRIC

WP# 6134-11-01 LOCATION Pagwachuan River Tributary Culvert N 5 515 454.8 E 411 164.4 ORIGINATED BY MNW
HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2014.06.07 - 2014.06.07 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W P W W L								
SHEAR STRENGTH kPa								WATER CONTENT (%)									
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																	
	Continued From Previous Page						20 40 60 80 100	20 40 60									
209.8			2	RUN		212								2	RUN #2 TCR=100% SCR=100% RQD=98% UCS=161MPa (Average) RUN #3 TCR=100% SCR=100% RQD=100% UCS=157MPa (Average)		
						211								0			
														1			
						210								2			
			12.7	END OF BOREHOLE AT 12.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2014.06.08 0.8 221.7 2014.06.09 0.9 221.6 2014.06.10 1.0 221.5 2014.06.12 1.2 221.3													1

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No PCT-02

2 OF 2

METRIC

WP# 6134-11-01 LOCATION Pagwachuan River Tributary Culvert N 5 515 442.7 E 411 153.0 ORIGINATED BY MNW
HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2014.06.10 - 2014.06.10 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				w _P w w _L				
								20 40 60 80 100	20 40 60							
	Continued From Previous Page															
213.7	Wet															
10.3	BEDROCK: MIGMATITIC GNEISS, dark grey, with white bands and occasional fractures		1	RUN			213								RUN #1 TCR=100% SCR=100% RQD=100% UCS=231MPa (Average)	
			2	RUN			212								RUN #2 TCR=97% SCR=93% RQD=88% UCS=187MPa (Average)	
			3	RUN			211								RUN #3 TCR=100% SCR=100% RQD=90% UCS=222MPa (Average)	
210.3																
13.7	END OF BOREHOLE AT 13.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, CONCRETE TO 0.1m, THEN COLD PATCH TO SURFACE.															

RECORD OF BOREHOLE No PCT-03

1 OF 2

METRIC

WP# 6134-11-01 LOCATION Pagwachuan River Tributary Culvert N 5 515 438.8 E 411 163.7 ORIGINATED BY MNW
 HWY 11 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.06.09 - 2014.06.09 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
224.0								20	40	60	80	100							
0.0	ASPHALT: (125mm)																		
0.1	SAND and GRAVEL, trace silt Very Dense Brown/Grey Moist (FILL)		1	SS	67													36 57 7 (SI+CL)	
223.0																			
1.0	SAND, some gravel, trace silt Compact Brown Wet (FILL)		2	SS	19														
			3	SS	11														
221.4	Thin organic layer		4	SS	22														
2.6	Silty CLAY, trace sand, trace gravel Stiff Greyish Brown																		
221.0																			
3.0	SAND, some gravel to gravelly, some silt Compact Dark Grey Wet		5	SS	13													26 54 20 (SI+CL)	
220.6																			
3.4	Sandy SILT, trace to some clay, trace gravel Loose Dark Greyish Brown Wet																		
			6	SS	8													2 32 58 8	
217.5			7	SS	9													0 38 50 12	
6.5	Silty CLAY, with silt seams Soft to Firm Dark Brown																		
			8	SS	1														
			9	SS	1													0 0 59 41	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No PCT-03

2 OF 2

METRIC

WP# 6134-11-01 LOCATION Pagwachuan River Tributary Culvert N 5 515 438.8 E 411 163.7 ORIGINATED BY MNW
HWY 11 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2014.06.09 - 2014.06.09 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100				w _p w w _L				
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
212.8	with till layers		10	SS	16		213									
11.2	BEDROCK: MIGMATITIC GNEISS, dark grey, with white bands and occasional fractures		1	RUN			212									
			2	RUN			211									
			3	RUN			210									
209.5																
14.5	END OF BOREHOLE AT 14.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.															

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W _P	W	W _L		
222.0 0.0	TOPSOIL, peaty Dark Brown Wet		1	SS	0								
221.7 0.3													
221.2 0.8	Silty CLAY, trace sand, trace organics Very Soft Brown		2	SS	1								
220.6 1.4	SILT, some sand, trace clay, trace wood pieces Very Loose Dark Greyish Brown Wet SILT, some clay, trace sand, trace gravel Loose to Compact Brownish Grey Moist		3	SS	10								
			4	SS	8								
219.0 3.0	Silty CLAY, trace sand, trace gravel Stiff Greyish Brown		5	SS	13								
217.1 4.9	Silty CLAY Firm to Very Soft Greyish Brown		6	SS	5								
	with till layers		7	SS	1								
213.9 8.1	Gravelly SAND, trace silt Compact Dark Brown Wet		8	SS	4								
212.2 9.8	BEDROCK: MIGMATITIC GNEISS,		9	SS	11								

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 1197.GPJ 2012TEMPLATE(MTO).GDT 8/13/14

RECORD OF BOREHOLE No PCT-04

2 OF 2

METRIC

WP# 6134-11-01 LOCATION Pagwachuan River Tributary Culvert N 5 515 425.3 E 411 151.2 ORIGINATED BY MNW
HWY 11 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2014.06.08 - 2014.06.08 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W P W W L				
								20 40 60 80 100				20 40 60				
	Continued From Previous Page		1	RUN			211							2	GR SA SI CL RQD=86% UCS=168MPa (Average) RUN #2 TCR=98% SCR=98% RQD=98% UCS=201MPa (Average)	
	dark grey		2	RUN										2		
														5		
														1		
														0		
209.7							210							0		
12.3	END OF BOREHOLE AT 12.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2014.06.09 0.2 221.8 2014.06.10 0.3 221.7 2014.06.12 0.3 221.7															

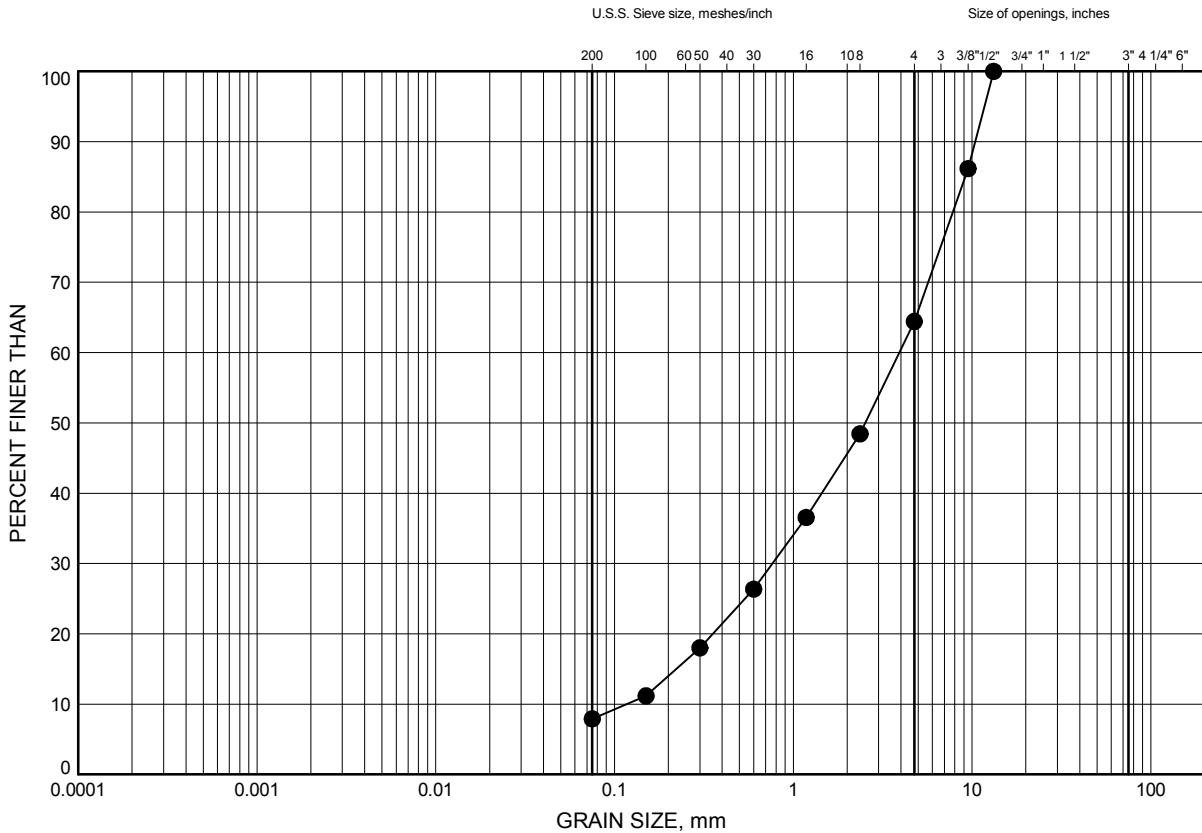
Appendix B

Laboratory Test Results

Pagwachuan River Tributary Culvert
GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-03	0.43	223.57

Date July 2014
WP# 6134-11-01

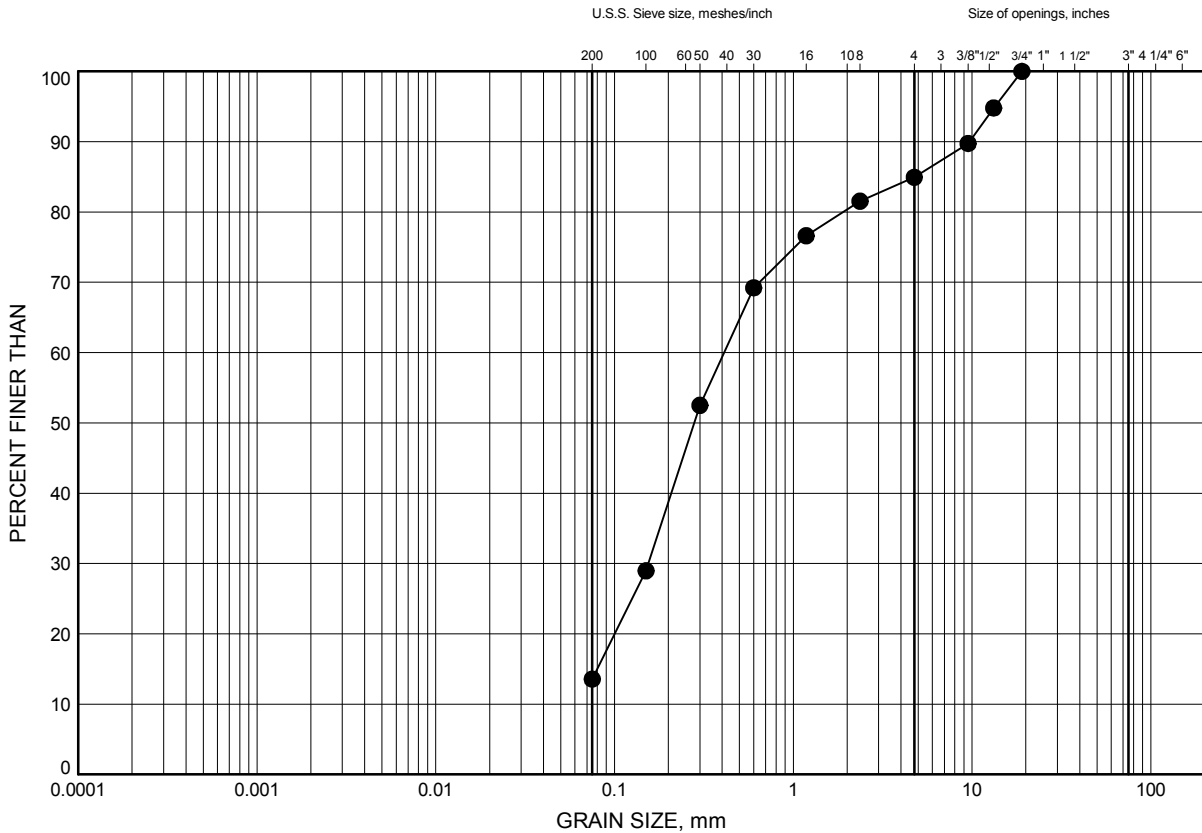


Prep'd AN
Chkd. MKE

Pagwachuan River Tributary Culvert
GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-02	1.83	222.17

Date July 2014
WP# 6134-11-01

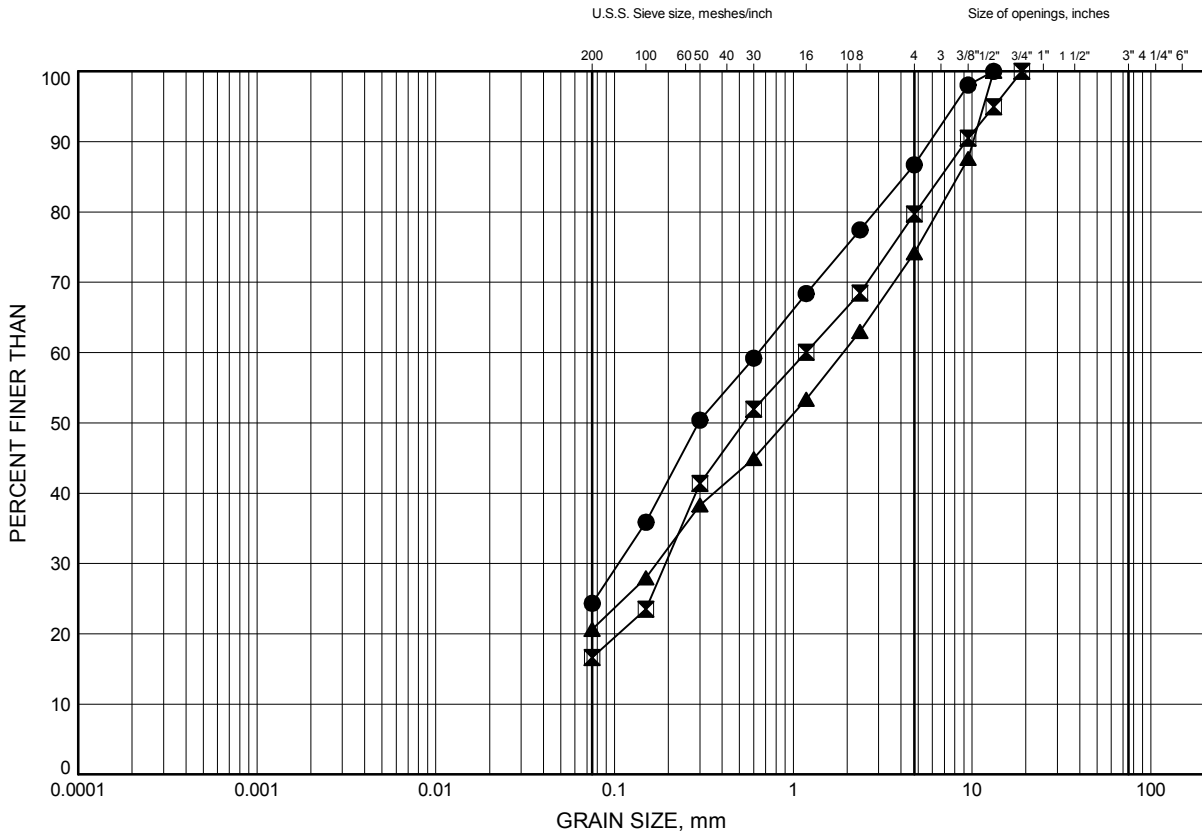


Prep'd AN
Chkd. MKE

Pagwachuan River Tributary Culvert
GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY SAND to SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-01	1.98	220.52
⊠	PCT-02	3.47	220.53
▲	PCT-03	3.20	220.80

Date July 2014
WP# 6134-11-01

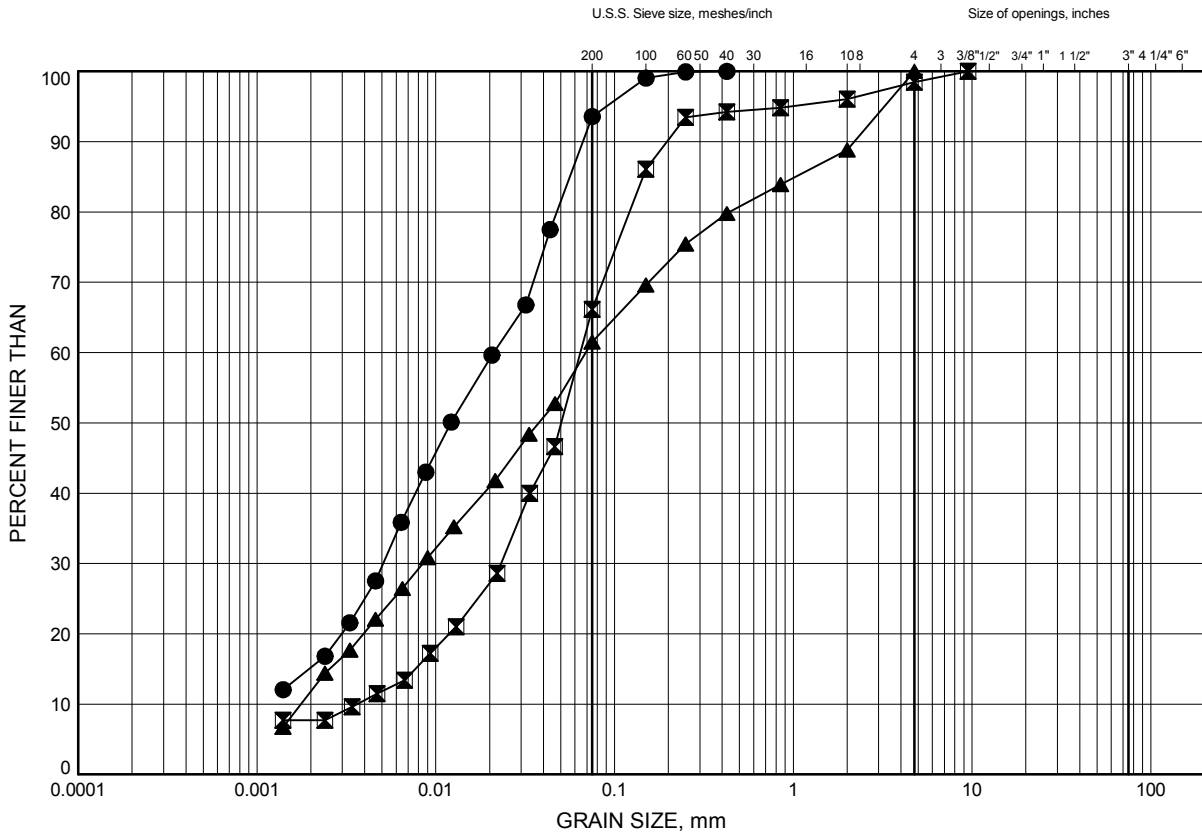


Prep'd AN
Chkd. MKE

Pagwachuan River Tributary Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4

SANDY SILT to SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-01	2.59	219.91
⊠	PCT-03	4.72	219.28
▲	PCT-03	6.29	217.71

Date July 2014
WP# 6134-11-01

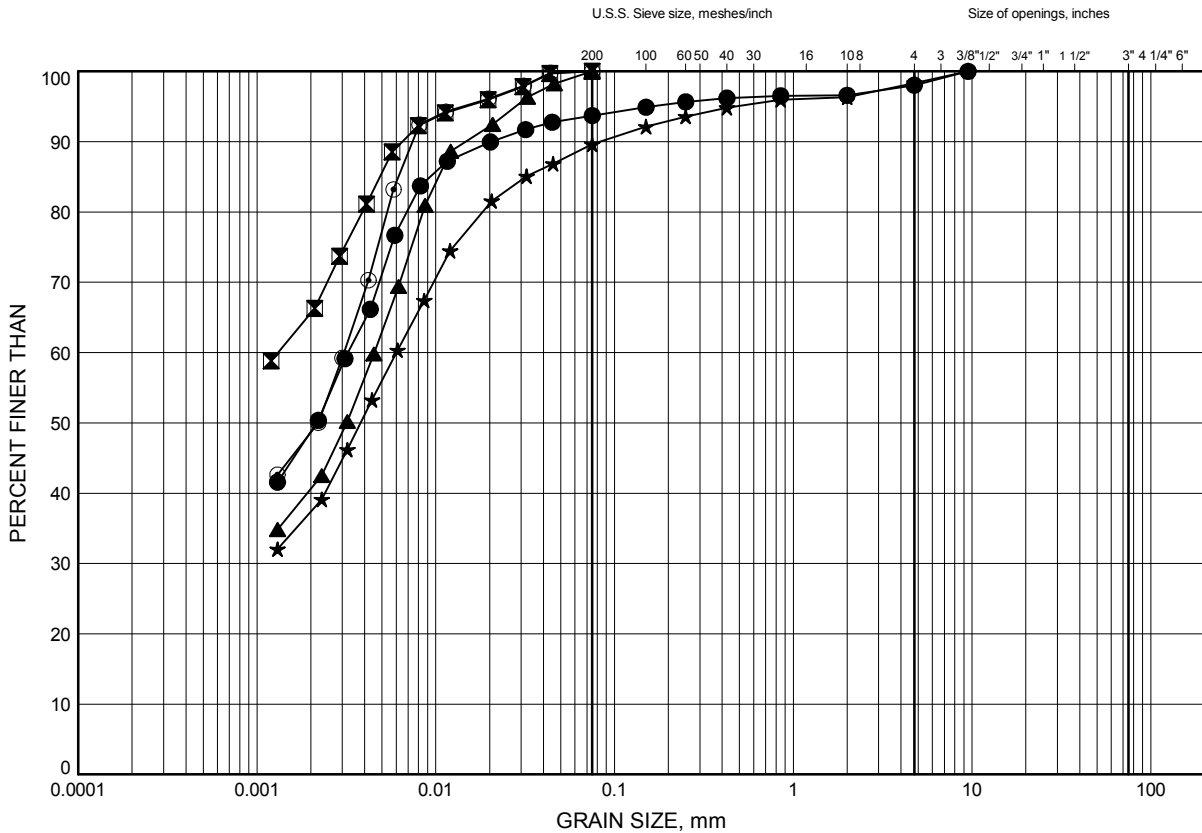


Prep'd AN
Chkd. MKE

Pagwachuan River Tributary Culvert
GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY to SILTY CLAY TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-01	6.40	216.10
⊠	PCT-02	7.92	216.08
▲	PCT-03	9.45	214.55
★	PCT-04	3.28	218.72
⊙	PCT-04	6.40	215.60

Date July 2014
WP# 6134-11-01

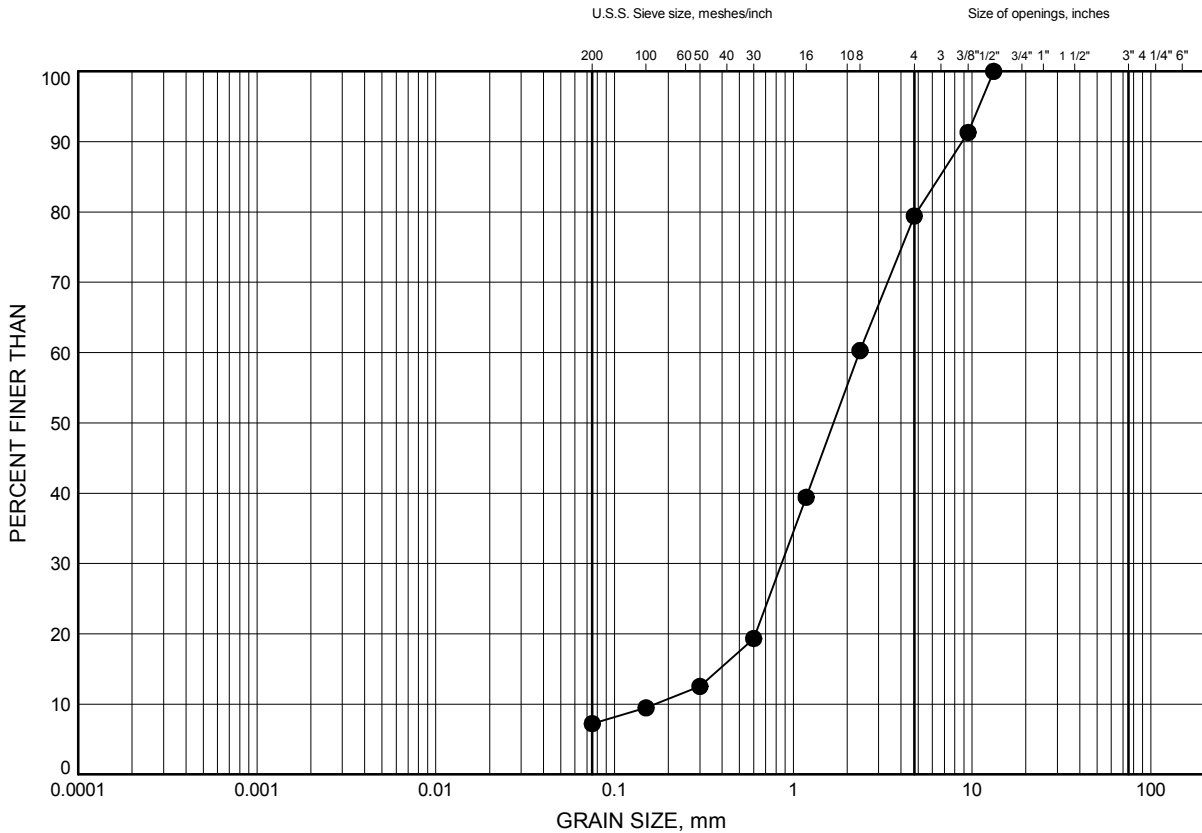


Prep'd AN
Chkd. MKE

Pagwachuan River Tributary Culvert
GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND & GRAVEL to GRAVELLY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-04	9.45	212.55

Date July 2014
WP# 6134-11-01

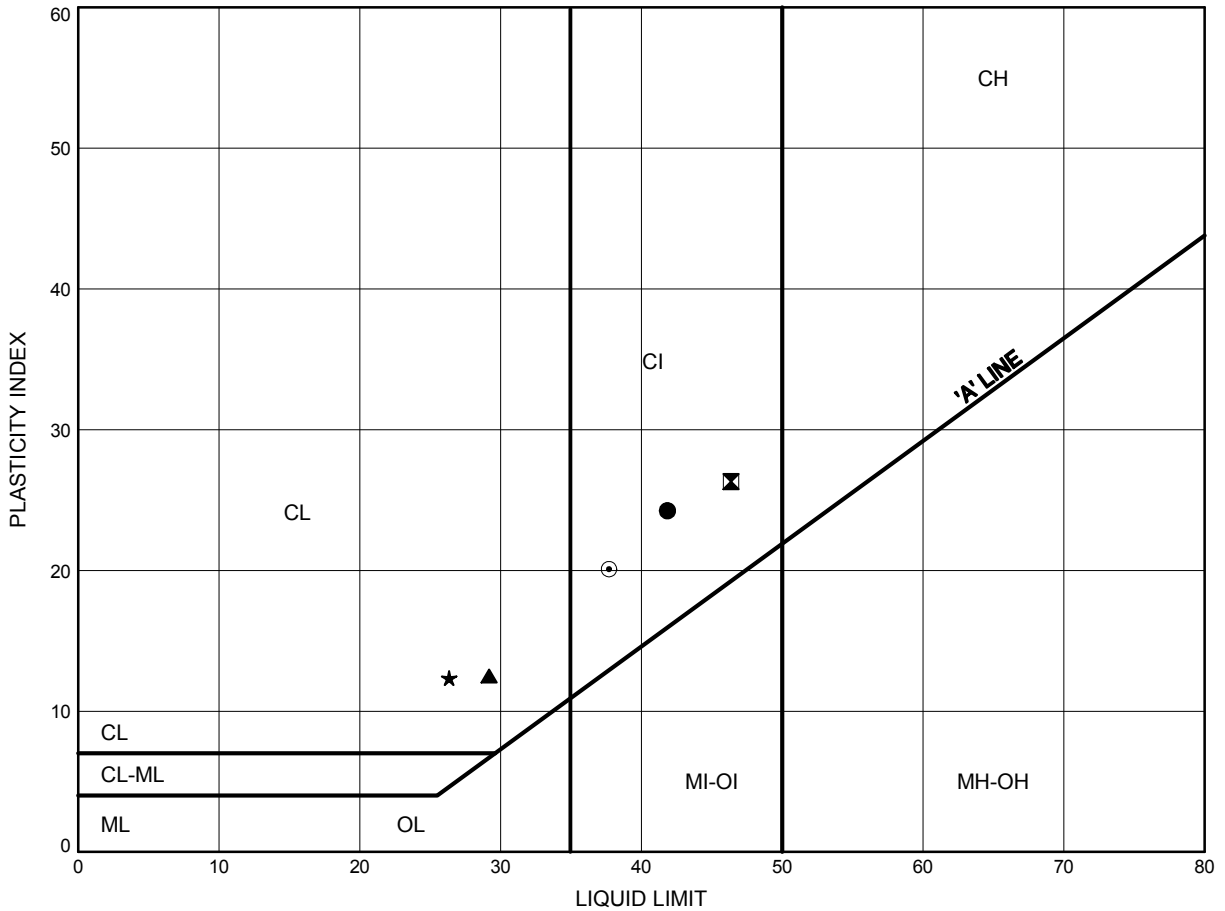


Prep'd AN
Chkd. MKE

Pagwachuan River Tributary Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY to SILTY CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCT-01	6.40	216.10
⊠	PCT-02	7.92	216.08
▲	PCT-03	9.45	214.55
★	PCT-04	3.28	218.72
⊙	PCT-04	6.40	215.60

Date July 2014
 WP# 6134-11-01



Prep'd AN
 Chkd. MKE

Appendix C

Site Photographs



Photograph 1 – South end of culvert, looking east at culvert outlet and highway embankment



Photograph 2 – South end of culvert, looking northeast at culvert outlet



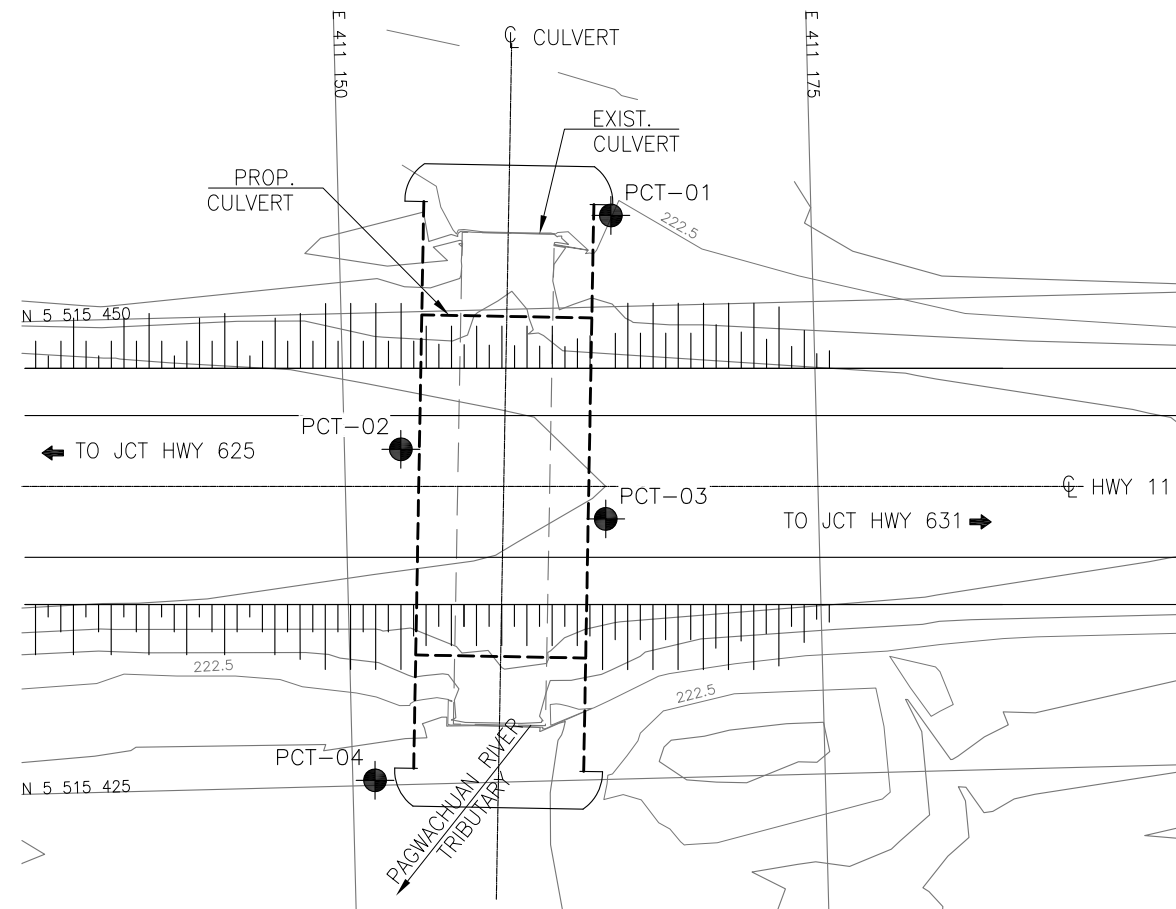
Photograph 3 – North end of culvert, looking northwest at culvert inlet and highway embankment



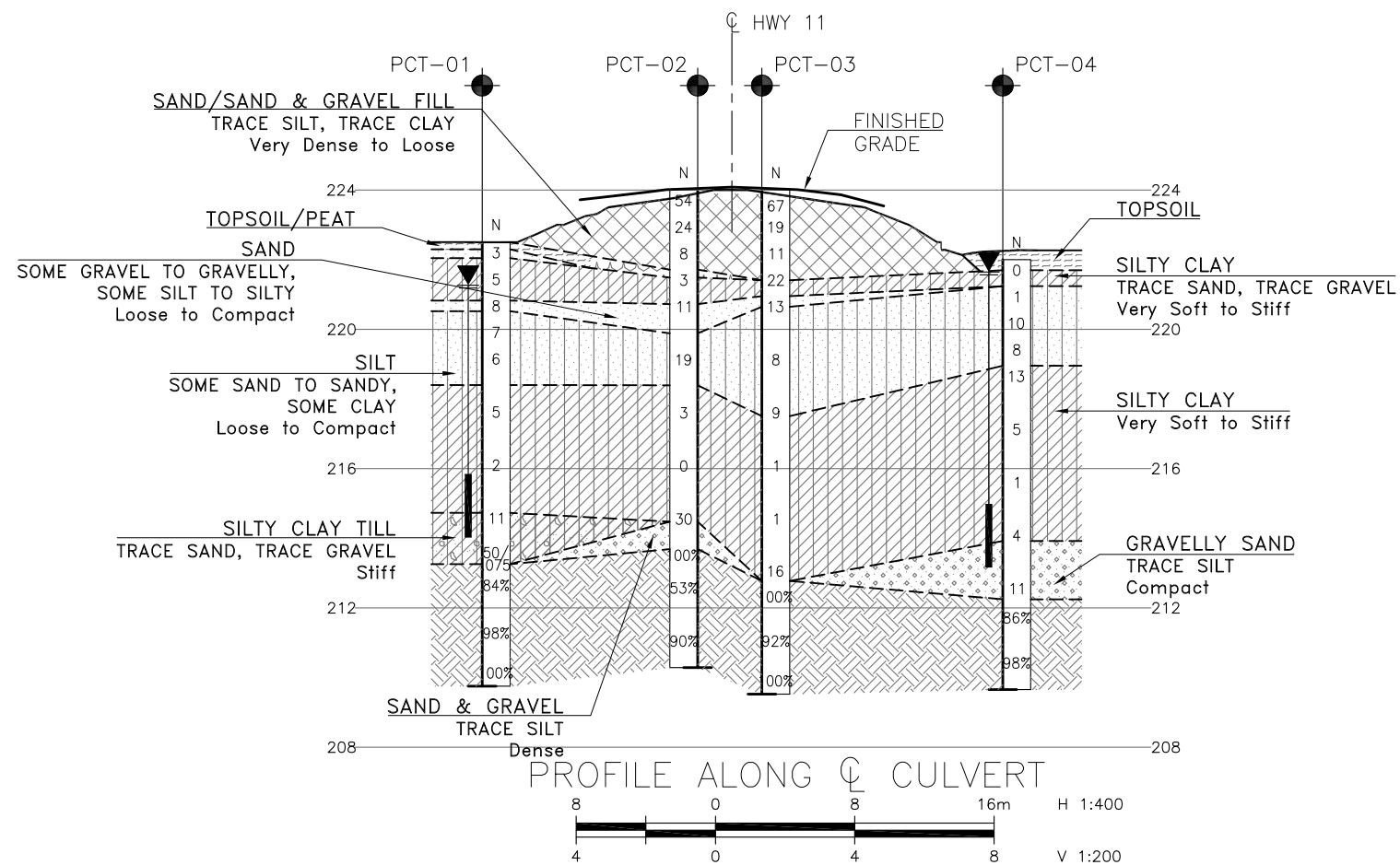
Photograph 4 – North end of culvert, looking southwest at culvert outlet

Appendix D

Borehole Locations and Soil Strata Drawing



PLAN

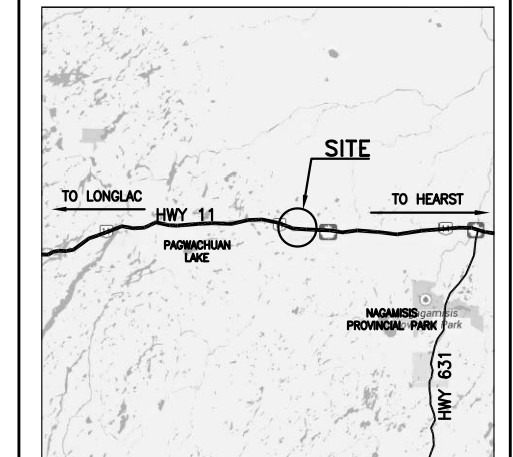


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 6134-11-01





HIGHWAY 11 PAGWACHUAN RIVER TRIBUTARY CULVERT REPLACEMENT BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
27



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level During Drilling
	Water Level In Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 42F-31

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	MEF	CHK	MEF	CODE	LOAD	DATE	AUG 2014		
DRAWN	AN	CHK		SITE 48F-69/C	STRUCT	DWG	2		